

THAT WHICH IS CLAIMED:

1. An apparatus for use with brake systems of a tow vehicle and a trailer towed by the tow vehicle, the apparatus comprising:

a vacuum supply sensor coupled to sense a vacuum supply of the trailer brake system, and generating a vacuum supply level signal based on a pressure of the vacuum supply;

an ambient pressure sensor generating an ambient pressure signal; and

a controller coupled to the vacuum supply sensor and to the ambient pressure sensor, the controller generating a vacuum pump switch signal based on the vacuum supply level signal and the ambient pressure signal.

2. The apparatus of claim 1 further comprising:

a vacuum pump coupled to the controller, and generating vacuum for the supply based on the vacuum pump switch signal.

3. The apparatus of claim 1 wherein the controller is programmed to determine a deactivation level for the vacuum pump switch signal.

4. The apparatus of claim 3 wherein the controller is further programmed to deactivate the vacuum pump switch signal from an activated state if the vacuum supply level signal represents a value that is equal to or greater than the deactivation level.

5. The apparatus of claim 3 wherein the controller is further programmed to determine the deactivation level by retrieving a value from its memory based on the ambient pressure signal, at least two different values for corresponding deactivation levels being stored in the memory.

6. The apparatus of claim 3 wherein the controller is further programmed to determine the deactivation level by retrieving a value from memory based on a current elevation of the trailer brake system, at least two different values for corresponding deactivation levels being stored in

the computer readable memory, the elevation of the apparatus and associated tow vehicle and trailer being determined from the ambient pressure signal.

7. The apparatus of claim 3 wherein the controller is further programmed to determine the deactivation level by performing a calculation based on the ambient pressure signal.

8. The apparatus of claim 7 wherein the calculation comprises an estimation of the current elevation of the trailer brake system based on the ambient pressure signal.

9. The apparatus of claim 1 wherein the controller is programmed to determine an activation level for the vacuum pump switch signal.

10. The apparatus of claim 9 wherein the controller is programmed to activate the vacuum pump switch signal from a deactivated state if the vacuum supply level signal represents a value that is equal to or less than the activation level.

11. The apparatus of claim 9 wherein the controller is further programmed to determine the activation level by retrieving a value from its memory based on the ambient pressure signal, at least two different values for corresponding activation levels being stored in the memory.

12. The apparatus of claim 9 wherein the controller is further programmed to determine the activation level by retrieving a value from memory based on an elevation of the trailer brake system, the elevation being determined from the ambient pressure signal.

13. The apparatus of claim 9 wherein the controller is further programmed to determine the activation level by performing a calculation based on the ambient pressure level signal.

14. The apparatus of claim 13 wherein the calculation comprises an estimation of the elevation of the trailer brake system based on the ambient pressure signal.

15. The apparatus of claim 1 wherein the vacuum supply sensor measures vacuum pressure relative to ambient air pressure, and the ambient pressure sensor measures absolute pressure.

16. The apparatus of claim 1 wherein the vacuum supply sensor and the ambient pressure sensor measure absolute pressure.

17. An apparatus for use with brake systems of a tow vehicle and a trailer towed by the tow vehicle, the apparatus comprising:

- an absolute pressure sensor coupled to sense a vacuum supply of the trailer brake system, and generating an absolute vacuum supply level signal based on an absolute pressure of the vacuum supply; and

- a controller coupled to the absolute pressure sensor, and generating a vacuum pump switch signal based on the vacuum supply level signal and the ambient pressure signal, the controller being programmed to activate the vacuum pump switch signal from a deactivated state when the vacuum supply signal level is less than or equal to a predetermined activation level, and further programmed to deactivate the vacuum pump switch signal from an activated state when the vacuum supply signal level is greater than or equal to a predetermined deactivation level.

18. An apparatus for use with brake systems of a tow vehicle and a trailer towed by the tow vehicle, the apparatus comprising:

- a vacuum supply sensor coupled to sense a vacuum supply of the trailer brake system, and generating a vacuum supply level signal based on a pressure of the vacuum supply;

- a GPS receiver generating a location signal representing a location of the trailer brake system;

- a controller coupled to the vacuum supply sensor and to the GPS receiver, the controller generating a vacuum pump switch signal based on the vacuum supply level signal and the location signal.

19. The apparatus of claim 18 further comprising:

a vacuum pump coupled to the controller, and generating vacuum for the supply based on the vacuum pump switch signal.

20. The apparatus of claim 18 wherein the controller is programmed to determine a deactivation level for the vacuum pump switch signal.

21. The apparatus of claim 20 wherein the controller is further programmed to deactivate the vacuum pump switch signal from an activated state if the vacuum supply level signal represents a value that is equal to or greater than the deactivation level.

22. The apparatus of claim 20 wherein the controller is further programmed to determine the deactivation level by retrieving a value from its memory based on the location signal, at least two values being stored in the computer readable memory.

23. The apparatus of claim 20 wherein the controller is further programmed to determine the deactivation level by performing a calculation based on the location signal.

24. The apparatus of claim 18 wherein the controller is programmed to determine an activation level for the vacuum pump switch signal.

25. The apparatus of claim 24 wherein the controller is programmed to activate the vacuum pump switch signal from a deactivated state if the vacuum supply level signal represents a value that is equal to or less than the activation level.

26. The apparatus of claim 24 wherein the controller is further programmed to determine the activation level by retrieving a value from its memory based on the location signal, at least two different values corresponding to respective activation levels being stored in the memory.

27. The apparatus of claim 24 wherein the controller is further programmed to determine the activation level by performing an arithmetic calculation based on the location signal.

28. The apparatus of claim 18 wherein the vacuum supply sensor measures vacuum pressure relative to ambient air pressure.

29. The apparatus of claim 18 wherein the vacuum supply sensor measures absolute pressure.

30. An apparatus for use with brake systems of a tow vehicle and a trailer towed by the tow vehicle, the apparatus comprising:

a vacuum supply sensor coupled to sense a vacuum supply of the trailer brake system, and generating a vacuum supply level signal based on a pressure of the vacuum supply;

an altimeter circuit generating an elevation signal; and

a controller coupled to the vacuum supply sensor and to the altimeter circuit, the controller generating a vacuum pump switch signal based on the vacuum supply level signal and the elevation signal.

31. The apparatus of claim 30 further comprising:

a vacuum pump coupled to the controller, and generating vacuum for the supply based on the vacuum pump switch signal.

32. The apparatus of claim 30 wherein the controller is programmed to determine a deactivation level for the vacuum pump switch signal.

33. The apparatus of claim 32 wherein the controller is further programmed to deactivate the vacuum pump switch signal from an activated state if the vacuum supply level signal represents a value that is equal to or greater than the deactivation level.

34. The apparatus of claim 32 wherein the controller is further programmed to determine the deactivation level by retrieving a value from its memory based on the elevation signal, at least two different values for corresponding deactivation levels being stored in the memory.

35. The apparatus of claim 32 wherein the controller is further programmed to determine the deactivation level by performing a calculation based on the elevation signal.

36. The apparatus of claim 30 wherein the controller is programmed to determine an activation level for the vacuum pump switch signal.

37. The apparatus of claim 36 wherein the controller is programmed to activate the vacuum pump switch signal from a deactivated state if the vacuum supply level signal represents a value that is equal to or less than the activation level.

38. The apparatus of claim 36 wherein the controller is further programmed to determine the activation level by retrieving a value from its memory based on the elevation signal, at least two different values for corresponding activation levels being stored in the memory.

39. The apparatus of claim 36 wherein the controller is further programmed to determine the activation level by performing a calculation based on the elevation signal.

40. The apparatus of claim 30 wherein the vacuum supply sensor measures vacuum pressure relative to ambient air pressure.

41. The apparatus of claim 30 wherein the vacuum supply sensor measures absolute pressure.

42. An apparatus for use with brake systems of a tow vehicle and a trailer towed by the tow vehicle, the apparatus comprising:

 a vacuum supply sensor coupled to sense a vacuum supply of the trailer brake system, and generating a vacuum supply level signal based on a pressure of the vacuum supply;

 at least one switch having at least two different positions and configured to supply a deactivation level selection;

 a controller coupled to the vacuum supply sensor and to the switch, the controller generating a vacuum pump switch signal based on the vacuum supply level signal and the ambient pressure signal, the controller being programmed to retrieve a deactivation level from its memory based on a position of the switch, and further programmed to deactivate the vacuum

pump switch signal from an activated state when the vacuum supply signal level is greater than or equal to the deactivation level retrieved from the memory.

43. An apparatus for use with driver-operated brake systems of a tow vehicle and a trailer towed by the tow vehicle, the apparatus comprising:

- a vacuum supply sensor coupled to sense a vacuum supply of the trailer brake system used to generate a vacuum control signal based on a brake fluid control signal generated by operation of the tow vehicle brake system by the driver, the vacuum supply sensor generating a vacuum supply level signal based on a pressure of the vacuum supply;

- an ambient pressure sensor generating an ambient pressure signal;

- a controller coupled to the vacuum sensor and to the ambient pressure sensor, the controller generating a vacuum pump switch signal based on the vacuum supply level signal and the ambient pressure signal; and

- a vacuum pump coupled to the controller, and generating vacuum for the supply based on the vacuum pump switch signal.

44. The apparatus of claim 43, further comprising:

- a control valve coupled to receive the brake fluid control signal and coupled to the trailer brake system, the control valve using the vacuum supply to generate the brake fluid control signal based on operation of the tow vehicle brake system.

45. A method comprising the steps of:

- a) sensing a pressure level of a vacuum supply;

- b) sensing a pressure level of ambient air;

- c) determining at least one of an activation level and a deactivation level based on the sensed ambient air pressure;

- d) comparing the sensed pressure level of the vacuum supply with the activation level and/or the deactivation level; and

- e) generating a vacuum pump switch signal based on the comparison in said step (d).

46. The method of claim 45 further comprising:

f) sensing a brake fluid signal used to operate a brake system of a vehicle towing a trailer;
and

g) generating a vacuum control signal with the vacuum supply to operate a trailer brake system, based on the brake fluid signal sensed in said step (f).

47. The method of claim 45 wherein the pressure of a vacuum supply is sensed in step (a) using a vacuum supply sensor.

48. The method of claim 45 wherein the pressure level of ambient air is sensed in step (b) using an ambient pressure sensor.

49. The method of claim 45 wherein the at least one of an activation level and a deactivation level is determined in step (c) using a controller.

50. The method of claim 45 wherein the sensed pressure level of the vacuum supply is compared to the activation level and/or the deactivation level in step (d) using a controller.

51. The method of claim 45 wherein the vacuum pump switch signal is generated in step (e) using a controller.

52. A method comprising the steps of:

a) sensing a pressure level of a vacuum supply;
b) determining an elevation of a trailer brake system;
c) determining at least one of an activation level and a deactivation level based on the elevation determined in step (b);

d) comparing the sensed pressure level of the vacuum supply with the activation level and/or the deactivation level; and

e) generating a vacuum pump switch signal based on the comparison in said step (d).

53. The method of claim 52 further comprising:

f) sensing a brake fluid signal used to operate a brake system of a vehicle towing a trailer;
and

g) generating a vacuum control signal with the vacuum supply to operate a trailer brake system, based on the brake fluid signal sensed in said step (f).

54. The method of claim 52 wherein the pressure of a vacuum supply is sensed in step (a) using a vacuum supply sensor.

55. The method of claim 52 wherein the elevation is determined in step (b) using a GPS receiver.

56. The method of claim 52 wherein the elevation is determined in step (b) using an altimeter circuit.

57. The method of claim 52 wherein the elevation is determined in step (b) based on an ambient pressure reading.

58. The method of claim 52 wherein the at least one of an activation level and a deactivation level is determined in step (c) using a controller.

59. The method of claim 52 wherein the sensed pressure level of the vacuum supply is compared to the activation level and/or the deactivation level in step (d) using a controller.

60. The method of claim 52 wherein the vacuum pump switch signal is generated in step (e) using a controller.